TECHNOSPHERE SAFETY

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Development of Measures to Improve Occupational Safety during Operation of Reservoirs in Spring

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Introduction. The paper considers the problem of ice formation on the spray ring of vertical steel tanks (VST) in spring, which threatens the safety of operating personnel when carrying out technological operations. The necessity of introduction of means of protection against ice is emphasized, which will make it possible to release commercial operators from performance of high risk operations of ice clearing from dry pipelines.
Problem Statement. The task of the research is to substantiate the use of possible ways of icing control on the tank spray ring.
Theoretical Part. As the basic information, the modern methods of de-icing used in mechanical engineering, oil industry and construction are presented.
Conclusions. As a result, the work proposes options for the use of means to fight against icing, through which the overall level of safety in the tank farm will increase.

Keywords: occupational safety, tank, spray system, icing, heating cable, anti-icing liquids.

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Introduction. The problem of icing of equipment and structures is acute for industrial sphere, because it directly affects their durability, as well as the level of safety during their operation. This is especially true for the northern regions of Russia, where temperature differences during the day in the period from March to May can reach more than 10°C [1].

Modern reservoirs located in the continental zone repeatedly experience a cycle of freezing and thawing of water that forms on the spray ring. The VST spray system is a ring of hollow pipelines located on the upper ring and designed to extinguish a fire at the time of ignition, as well as to cool the wall of a burning tank. When an emergency situation occurs, the spray system also works on neighboring structures to eliminate the possibility of fire spreading. On the dry pipes of the spray system there are technological openings for the supply of spray water. In spring, melt water crystallizes on the ring when negative temperatures occur at night, as a result of which ice forms on it, which can reach more than 2 m in length even with regular cleaning.

The accumulation of large masses of ice on the spray ring makes life-threatening the following daily production operations performed by commercial operators [2]:

– opening and closing of the main gate valves;
– sampling;
– drainage of water bottoms;
– measurement of the oil product innage;

– maintenance of the equipment located at the base of the tank (siphon crane, bottom sediment washing device, receiving and distributing device, etc.).

The gravity of ice masses continuously acting on the dry pipe can lead to wear and destruction of the equipment. In addition, it is possible to disrupt the normal functioning of the spray system in case of emergency situations.

The seasonality problem is typical only for spray ring tanks operated in the north of the country. This sets a very narrow range of its distribution, prevents the oil industry from developing general standards to protect the spray ring from ice, so enterprises cope with its consequences on their own [3, 4].

Problem Statement. The main objective of the study is to substantiate the use of technical and chemical means of ice control on the spray ring of the VST to improve the reliability of equipment and safety of operational personnel.

At the moment, the main way to deal with ice is mechanical cleaning of the dry pipe by commercial operators using a working tool, because often there are no specialized scrapers on the site. This method of ice removal can lead to damage to the tank shell, and the uncontrolled fall of the knocked-down ice threatens the equipment on the first ring.

The process of cleaning ice masses refers to high-risk operations, since a number of dangerous factors begin to act on the operator [5]:

– height of more than 1.8 m;

– slippery surface that can cause a fall;

– uncontrolled fall of knocked off ice;

– the impact of meteorological factors (wind, snow);

– physically hard work, time-consuming.

Therefore, in order to avoid possible injuries and falls, enterprises should develop regulatory documentation regulating this process and provide a list of copper-plated equipment suitable for cleaning hazardous industrial facilities.

Reduction of the volume of high-risk work performed, as well as the existing harmful and hazardous production factors, is one of the tasks of occupational safety at hazardous production facilities. The development of appropriate documentation does not solve this problem [6, 7]; therefore it is necessary to consider alternative options for icing control.

Theoretical Part. The prevention of ice formation can be considered as a promising direction in solving the problem of icing. The oil industry has long used specialized heating cables in explosion-proof design for heating oil products in railway tanks, tanks, pipelines. One of the main characteristics of cables is their ability to self-regulate the heating temperature depending on the external environment. A special self-regulating matrix of the cable is able to reduce the passing electric current along special conductor paths due to the expansion of the polymer inside the cable at a positive ambient temperature, and vice versa, to increase the heating temperature due to an increase in current when the polymer shrinks [8].

Justification of the possibility of introducing a heating cable to the tank spray ring should begin with an analysis of industrial safety documentation. The use of electrical equipment in explosion-proof design on the premises is permissible according to GOST12.2.020-76. Now there are a large number of companies specializing in industrial heating of equipment and structures, so that problems with cable selection do not arise.

The main task when selecting a heating cable is the question of its position during installation. There are several options here:

– spiral mounting;

– installation along the dry pipe line.

Spiral mounting is used for heating pipes of relatively small diameter. This method lays the cable in coils and allows you to warm up a large surface area. Its obvious disadvantage is that the dry pipe is a perforated pipe, and the overlap of these holes will disrupt the normal operation of the equipment.

It would be preferable to fix the heating cable parallel to the dry pipe from above. Thus, the cable will always be visible during inspection, meltwater will not drain onto it, and there will also be no obstacle to the operation of the irrigation system. In Fig. 2, the heating cable on the spray ring is indicated in black.

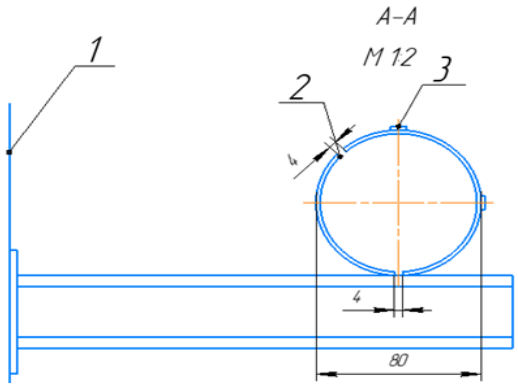

Fig. 1. The layout of the heating cable on the irrigation ring of the VST:
1 — VST wall; 2 — technical hole; 3 — heating cable

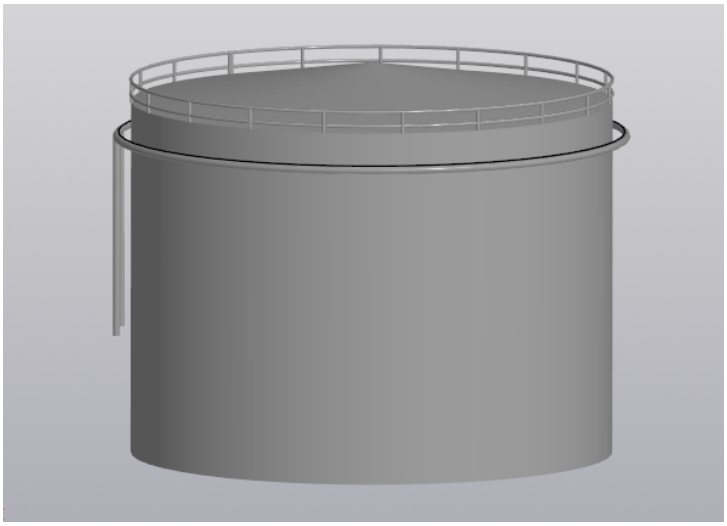

Fig. 2. 3D model of a tank with a heating cable

Although at the moment there are many options on the market for heating cables, a universal one with all the required technical characteristics has not yet been offered. This may be a direction for further research on the problem of protection from icing of reservoirs.

The introduction of a heating cable on the spray ring of the tank effectively solves the problem of icing and the formation of ice, which reduces the likelihood of accidents and complication of the spray system.

Another way to control icing is the use of special de-icing liquids (DIL). The chemical method is used in the aviation industry to protect aircraft before flight. In addition, hydrophobic compounds are used to treat roofs and cornices of public buildings [9].

The basis of de-icing compositions are organosilaxanes or other polymers, which, after the addition of additives in the form of chemical fillers, solvents and corrosion inhibitors, allow the coating to obtain an anti-adhesive structure that works on the principle of reducing the adhesion of the surface to the liquid, so that water drains without having time to crystallize.

After the treatment with de-icing compositions, the surface acquires a number of properties:

– hydrophoby;

– fire resistance;

– resistance to atmospheric precipitation;

– anticorrosion.

Long service life and low economic costs of coating can make the chemical method the most popular one among the proposed solutions. Coating the spray ring with a hydrophobic composition in theory can show an excellent result.

At the moment, the optimal composition of de-icing liquids has not been proposed, so further research in this direction is relevant.

Thus, the use of special de-icing liquids can solve the problem of icing and the formation of ice that forms on the spray ring of tanks, which also reduces the likelihood of accidents and difficulties in the operation of the spray system.

Conclusions. The existing problem of icing threatens the safety of operational personnel [10]. The study suggests the effective methods to control icing. The introduction of the proposed methods will improve the safety of the operation of tanks in the most dangerous period of the year. In order to choose the most suitable method, it is necessary to check them in practice.

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